THE WEATHER AND CIRCULATION OF MAY 1967

Strong Blocking and Record Cold in the East

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1. MONTHLY MEAN CIRCULATION

Strong blocking in the Bering Sea in May 1967 contributed to the deep trough over eastern North America (figs. 1 and 2). This trough extended from the Polar Basin to the low latitudes and brought cold, wet weather to the eastern two-thirds of the United States.

Transition of the circulation from April to May was characterized by large, non-seasonal height changes. These are shown in figure 3 and in a general way reflect the blocking in the form of high-latitude positive height changes. The month-to-month height anomaly changes resulted when troughs in April (fig. 1 of [1]) were replaced by ridges in May, and ridges were replaced by troughs. This was accompanied by apparent progression of the systems in the central Pacific to central United States while retrogression seemed to occur in the Atlantic.

As the blocking ridge became established over the Bering Sea, heights increased there by 400 ft. and decreased by 200 ft. east of Japan. With heights as much as 450 ft. above normal in the Bering Sea, the flow was split characteristically with one branch near 70°N. and another along 40°N. Despite this split the southern branch of the westerlies was displaced little from normal (fig.4). The reversal in the eastern Pacific was associated with the change in circulation in the Bering Sea. A Low developed in the Gulf of Alaska where heights decreased by more than 500 ft. The full-latitude ridge of April was replaced by the new trough in May and moved eastward as 700-mb. westerlies increased in middle latitudes. Some shearing of this ridge also took place as often happens with the wind speed differential between 30° and 50°N. As the northern portion of this ridge moved into western North America, 700-mb. heights increased by more than 300 ft. along the west coast. The trough that was displaced moved from the west coast to central United States as the upper portion sheared and the lower portion remained near Baja California. The principal consequence in the United States of the circulation evolution was the change of exposure of the Nation to strong influxes of cold air. In contrast, during April the strong southwesterly flow produced confluence with northwesterly flow in Canada and constrained the transport of cold air to Canadian latitudes.

The strong ridge of April in the Atlantic became re-established about 15° of longitude farther west this month as a blocking High formed over Greenland. Meanwhile an unusually deep Low (−400-ft. height anomaly) appeared near the United Kingdom with sea level pressure 12 mb. below normal. The upper-level trough with which the Low was associated was about 30° of longitude west of its April position. This is a very unusual place for a trough in May, although cyclonic curvature is common in the eastern Atlantic in subsequent warm months.

Downstream from the eastern Atlantic trough and associated with the southwesterly flow across Europe and the northwesterly flow across the Arctic were above normal heights and thicknesses. These indicate unseasonably warm weather for most of Europe and Russia. The moderate vortex east of Novaya Zemlya provided flow for the transport of cool air into western and central Siberia. Rather flat anticyclonic flow, only slightly different from the normal flow, prevailed over the balance of Asia north of 30°N. The principal jet axis over Asia was considerably farther north than normal, another indication of the overall restriction of cold air masses to high latitudes.

2. TEMPERATURE

Reversal in the monthly mean 700-mb. circulation this month was accompanied by marked changes in temperature across the Nation. The May temperature decreased one to four classes at 67 out of 100 cities while temperatures increased by one to three classes at one-fourth of the cities. Persistence of temperature from April to May was low this year as less than one-third remained the same or changed by one class. All the positive temperature changes of two or three classes were confined to the Far West in an area dominated by a ridge and positive height anomalies. Negative temperature changes of three to four classes were spread over most of the Ohio Valley, the Southeast, and portions of the lower Mississippi Valley.

This was a cool May except in the Far West and in Florida and southern Texas (fig. 5). In these areas temperatures were normal to a few degrees above normal. As the ridge developed along the west coast there was a junction of the height anomaly contours (fig. 2) with the blocking over the Bering Sea. This amalgamation produced

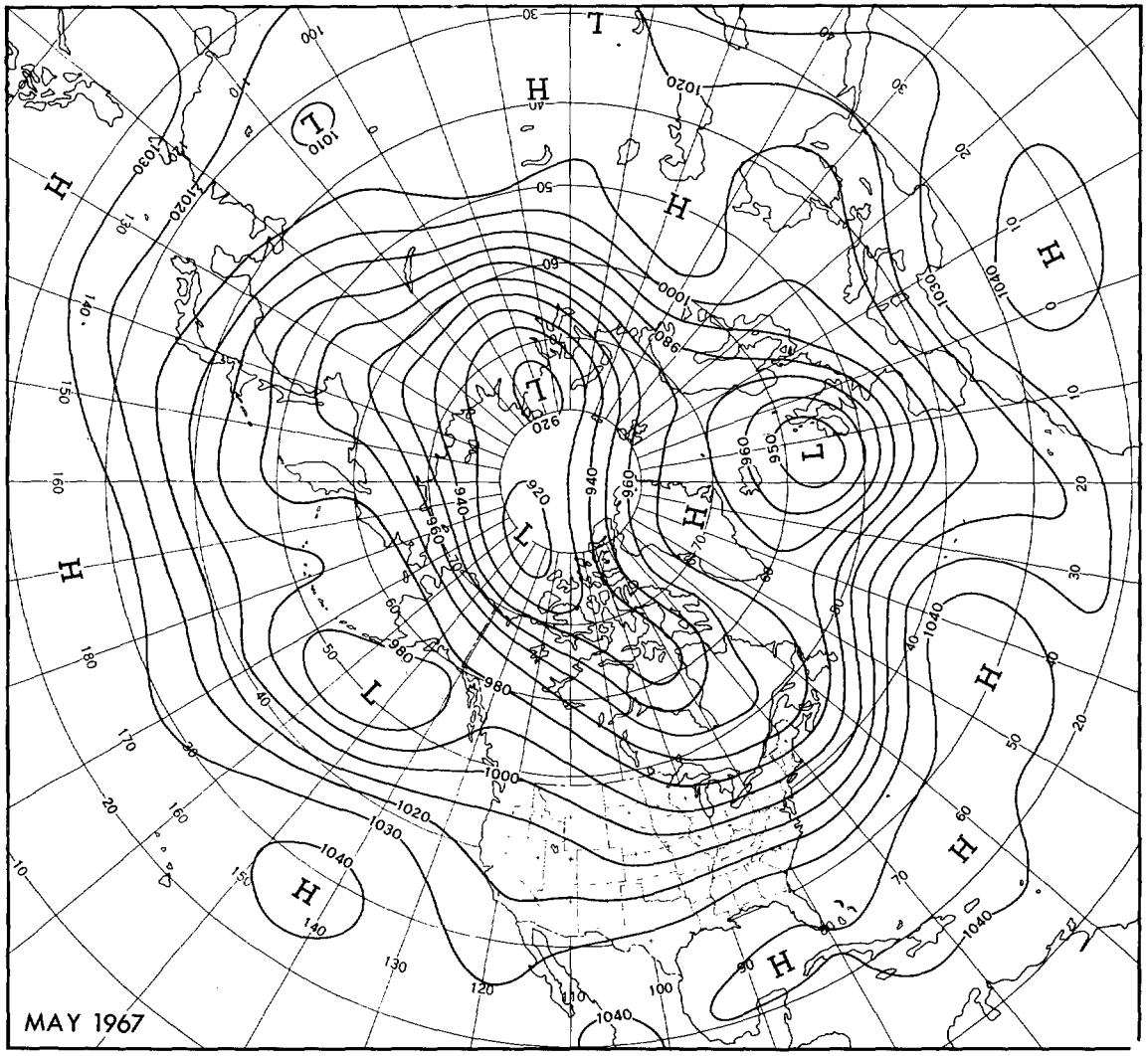

FIGURE 1.—Mean 700-mb. contours (tens of feet) for May 1967. Blocking in the Bering Sea and Greenland were primary factors in maintaining the deep mean trough over eastern North America.

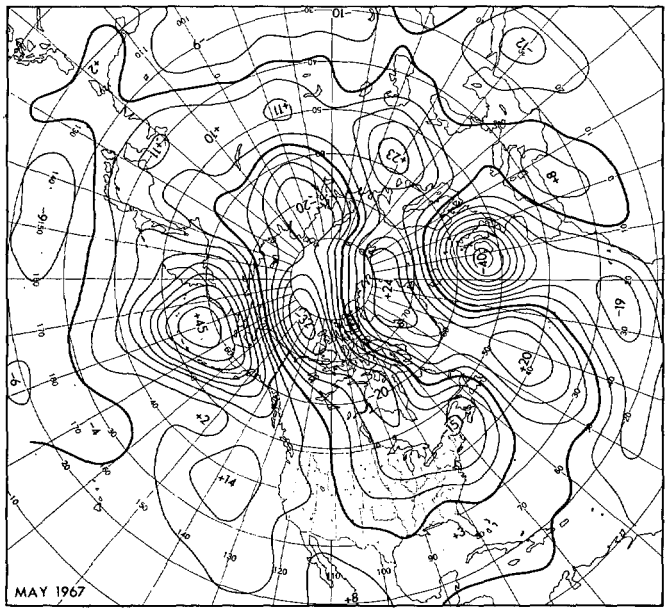

FIGURE 2.—Departure from normal of mean 700-mb. height (tens of feet) for May 1967. Amplified anomalous flow encouraged strong transport of air from the Arctic into the United States east of the Rockies.

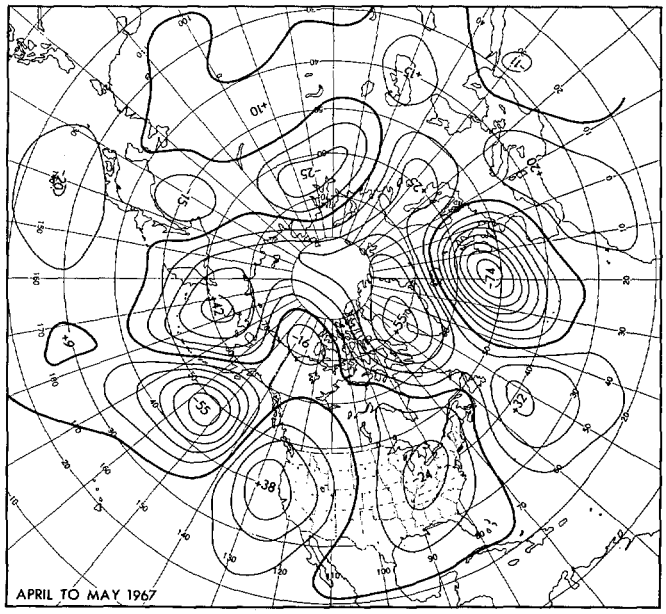

FIGURE 3.—Mean 700-mb. height anomaly change (tens of feet) from April to May 1967. The circulation reversal from April to May over the western portion of the Northern Hemisphere is shown in the alternating centers of change in middle latitudes.

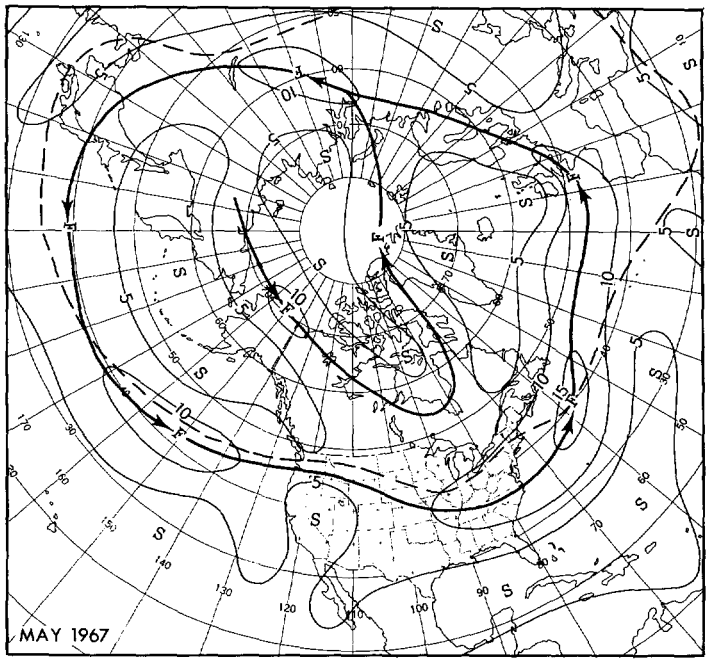

FIGURE 4.—Mean 700-mb. isotachs (meters per second) for May 1967. Solid arrows indicate principal axes of maximum wind speed and dashed lines the normal. The northern branch of the westerlies created a well-defined jet at high latitudes. Wind speeds were 9 m.p.s. above normal near Point Barrow, Alaska, and 6 m.p.s. above normal near northern Greenland.

a strong flow from the Polar Basin which affected the eastern two-thirds of the Nation. While Pacific air masses were not excluded, the average flow transported predominantly continental polar air masses east of the Rockies. Lowest mean temperatures were 4°–8°F. below normal in the northern half of the United States east of the Rockies. Many new monthly mean records for May were established and are shown in table 1.

3. PRECIPITATION

Drought had become severe in Florida and severe to extreme from Texas to Kansas through the first three weeks of May (see Palmer's drought severity map [2]). Some short relief of agricultural drought occurred in the Southern Plains as showers fell during the last ten days of May. Meteorological drought persisted, however, over a large area through June 2 [2]. At Grand Island, Nebr., for example, the deficiency since October 1965 was 12.67 in. In Florida, relief came to northern areas as a cold front moved through and produced heavy showers on May 22 and 23. Gainesville had 3.5 in. at this time, but total monthly amounts in central and southern Florida were only 25 percent or less of normal (fig. 6). Lakeland reported the longest spring drought of record.

Normal or greater precipitation was widespread this month under the broad, generally cyclonic, 700-mb. flow (figs. 1 and 2) across the Nation. Less than normal precipitation in the Northwest was associated with the anticyclonic mean flow and the northerly anomalous flow.

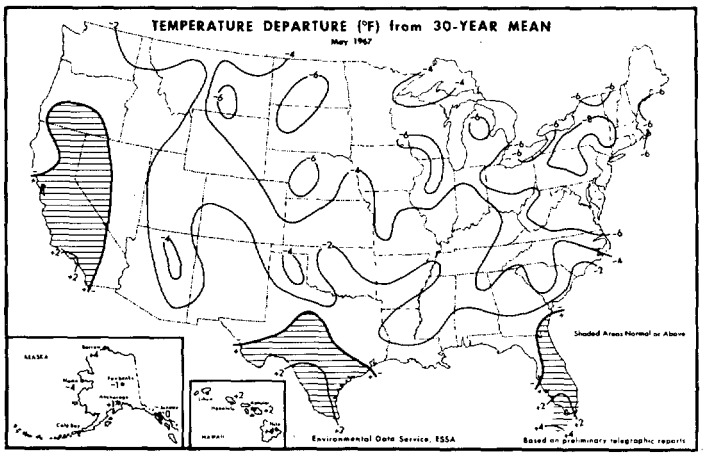

FIGURE 5.—Departure from normal of average surface temperature (°F.) for May 1967 (from [2]). Reversal of circulation this month was accompanied by a reversal of temperature in which 67 of 100 cities were cooler by one to four classes.

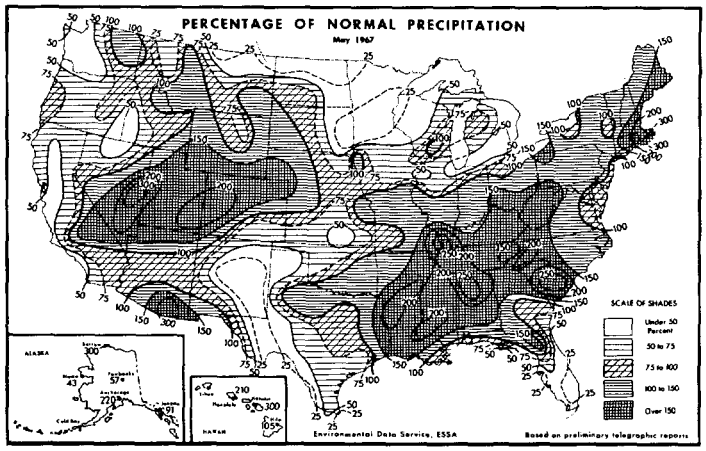

FIGURE 6.—Percentage of normal precipitation for May 1967 (from [2]). Generally less than normal precipitation from Kansas to Texas prolonged the serious drought. Some relief came to northern Florida but south and central portions received only 25 percent of normal rainfall.

TABLE 1.—*Monthly mean record temperatures for May established in 1967*

City	Mean temperature (° F.)	Mean temperature anomaly (° F.)
Bridgeport, Conn.	51.1	−7.6
New Haven, Conn.	51.2	−6.0
Nantucket, Mass.	47.5	−5.1
Pittsfield, Mass.	47.5	−7.1
Worcester, Mass.	48.8	−6.4
Albany, N.Y.	50.4	−7.5
Newark, N.J.	54.3	−7.7
Allentown, Pa.	52.8	−7.6
Harrisburg, Pa.	55.2	−7.5
Philadelphia, Pa.	55.9	−6.7
Lynchburg, Va.	58.8	−6.5
Norfolk, Va.	61.2	−6.3
Roanoke, Va.	59.0	−6.7
Youngstown, Ohio	50.2	−7.7
Temperatures in the following cities set records for lowest since 1917		
Portland, Maine	48.8	−6.4
Boston, Mass.	51.7	−7.1
Trenton, N.J.	56.4	−5.9
Washington, D.C.	60.0	−5.8
Cleveland, Ohio	52.3	−5.7

As much as three times normal fell in the Great Basin and in the central Rockies including several inches of snow as short waves moved through. Precipitation was below normal in the Northern Plains and in portions of the Southwest, as often happens when the 700-mb. flow is westerly or northwesterly over the Rockies.

The average flow aloft this month did not indicate prolonged transport of moisture from the Gulf of Mexico or the Atlantic. However, at sea level (chart X of [3]) there was a sustained flow across the Gulf Coast States to the Midwest. Here the low-level flow turned eastward as it met the strong upper-level flow (see 700-mb. jet axis in fig. 4), so moisture was generally available over the eastern half of the United States where precipitation was above normal except in the Great Lakes and central and southern Florida. More than twice normal fell from Louisiana to West Virginia, with over 10 in. at Cairo, Ill., of which 6.15 in. fell on May 14 during strong convective activity.

Heavy precipitation also occurred in southern New England, most of which fell with the passage of one coastal storm. The same storm that affected the Southeast and produced a 24-hr. record for May at Charleston, S.C. (4.85 in. on the 22d) moved along the coast but slowed near southern New England as blocking developed over the Maritime Provinces. Nantucket, Mass., had the wettest May of record with a total rainfall of 10.38 in. (7.50 in. above normal). Providence, R.I., had a record 24-hr. total for May of 3.76 in. with this storm. Sleet and snow fell over portions of western New England and 9 in. of snow was reported in southwestern New Hampshire. High winds caused beach erosion and some heavy damage in coastal areas. A few of the cities with strong winds include Boston, Mass. (50 m.p.h.), Bridgeport, Conn. (50 m.p.h.), and Nantucket, Mass. (49 m.p.h.).

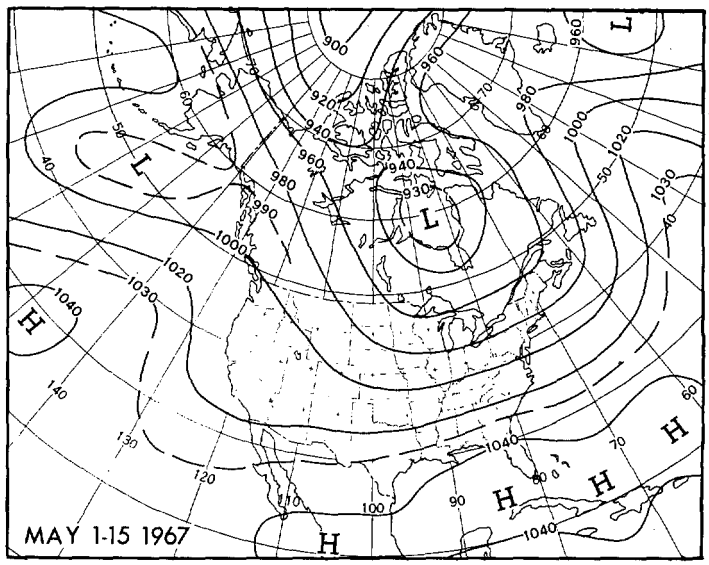

FIGURE 7.—Mean 700-mb. contours (tens of feet) for May 1–15, 1967. Broad cyclonic flow over the United States was accompanied by lower than normal temperatures except in Gulf Coast States.

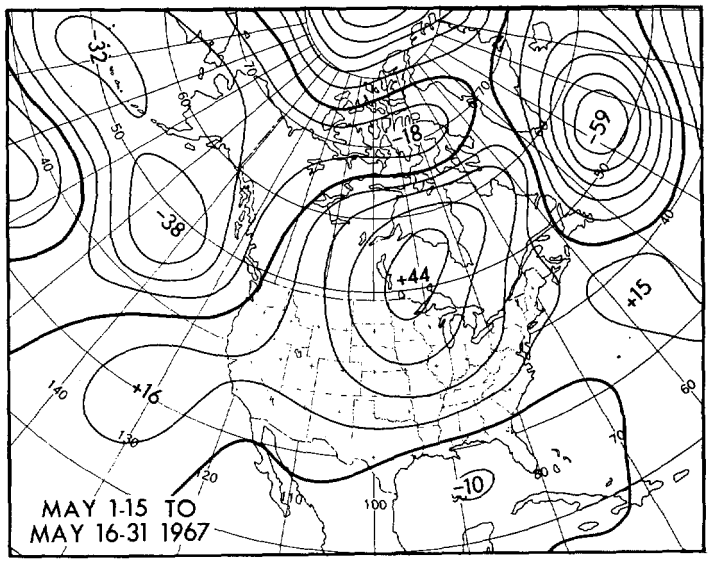

FIGURE 8.—Mean 700-mb. height change (tens of feet) from May 1–15 to May 16–31, 1967. Large increases over the United States and Canada show deamplification of the deep trough of the first half of May.

4. HALF-MONTHLY VARIABILITY

MAY 1–15

During the first half of May (fig. 7) the 700-mb. flow into the Nation was from two sources. There was cool maritime flow into the West and a flow from cold Arctic sources into the East. The Gulf of Alaska Low and southwesterly flow in the eastern Pacific effectively kept the coldest air out of the West, while the very strong Polar vortex and deep Low over Hudson Bay provided a strong transport of Arctic air into the eastern two-thirds of the country. Temperatures averaged 8°–14°F. below normal in the Central and Northern Plains during the first half of the month, and in the East departures of 4°–5°F. were common. Only in the Gulf Coast States were temperatures normal and above with averages of 4°–6°F. above in southern Texas.

Precipitation amounts were not totaled for the first 15 days but during the first week precipitation was quite heavy in the eastern one-third of the United States. Here amounts averaged 2–4 in. from the central Gulf States to the Ohio Valley and northeastward. This week blizzard conditions prevailed in portions of the Northern Plains States. As a vigorous short wave moved out of the west coast trough, the developing surface storm left 11 in. of snow at Bismarck, N. Dak., a new 24-hr. record for so late in the spring. Snow was also heavy in Wyoming and Nebraska for this time of year. Other weather extremes of note were tornadoes and hail over the Central and Southeastern States.

As another severe storm came out of the West during the second week and deepened in the Midwest, the border areas again received snow. Helena, Mont., reported 12.5

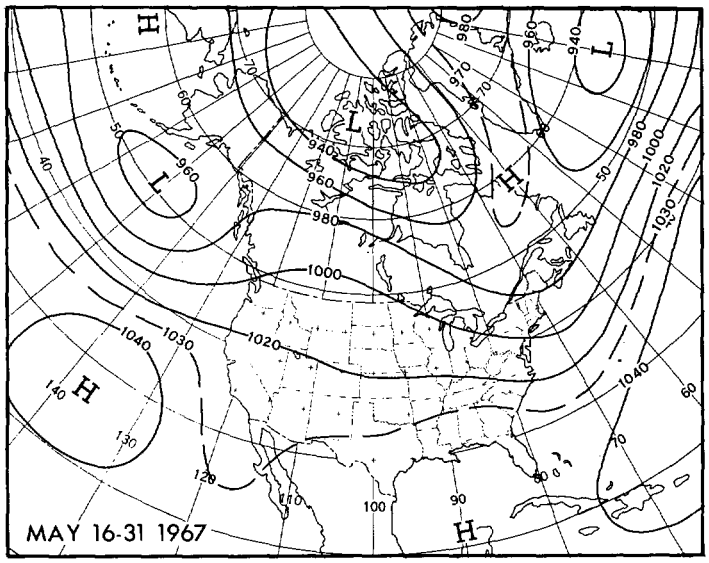

FIGURE 9.—Mean 700-mb. contours (tens of feet) for May 16–31, 1967. Temperate latitude (35°–55°N. and 5°W.–175°E.) flow the second half of May was 1.6 m.p.s. faster than normal compared with 2.4 m.p.s. slower than normal in the first half of May.

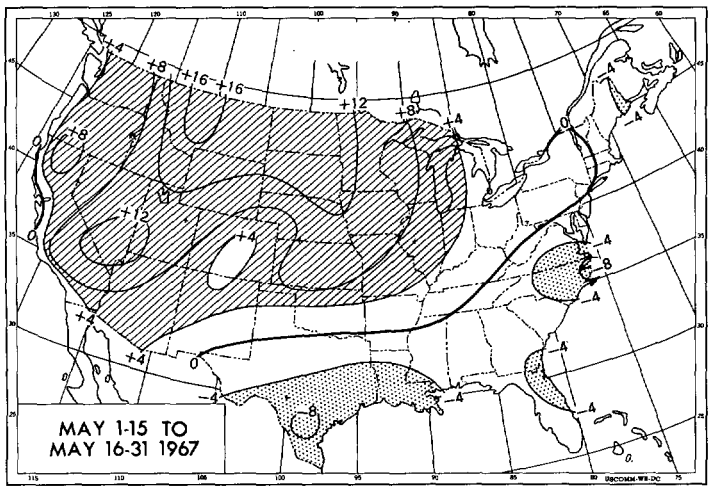

FIGURE 10.—Temperature anomaly change (°F.) for May 1–15 to May 16–31, 1967. Widespread warming was associated with the mid-month circulation reversal.

in., a new 24-hr. record for May. Snow also fell over the Rockies and the Great Lakes. Widespread severe storms and hail accompanied this storm as it moved rapidly through the Northern Plains, across the Ohio Valley, and off the east coast. Excessive precipitation was confined to local areas in the Mississippi and Ohio Valleys, where 1–2 in. was general, with over 4 in. in western Kentucky and southern Illinois.

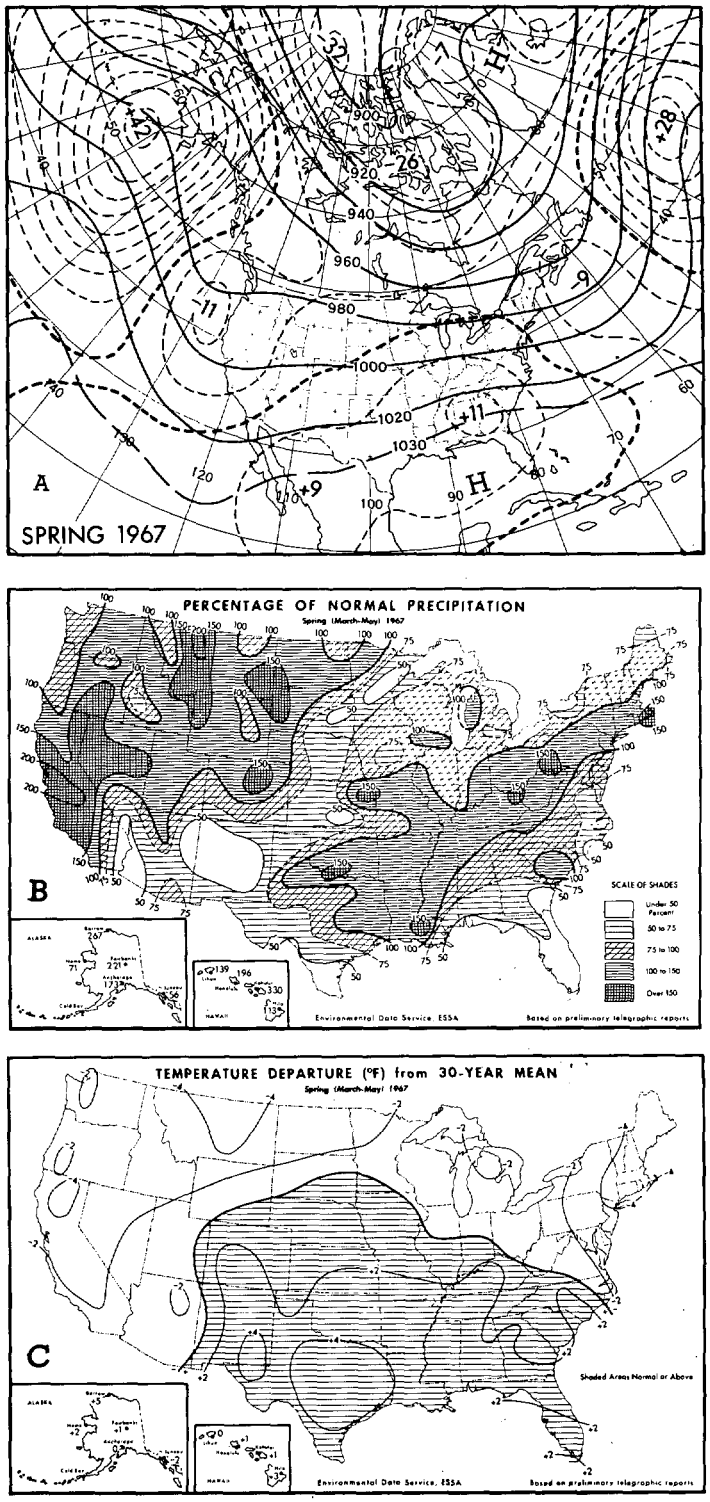

FIGURE 11.—Spring 1967. (A) 700-mb. contours (solid) and height departure from normal (dashed) (both in tens of feet); (B) departure from normal of average surface temperature (°F.) (from [2]); (C) percentage of normal precipitation (from [2]).

MAY 16–31

Great circulation changes occurred from the first half of May to the last half (fig. 8). Heights at 700 mb. decreased more than 300 ft. in the Gulf of Alaska and the Arctic Low weakened by several hundred feet. Over the

United States and most of Canada the strong trough and wintry circulation of the first half of the month were replaced by ridging (fig. 9) and a marked warming as heights increased by as much as 440 ft. in western Ontario. Temperature response to these changes is shown in figure 10, the temperature anomaly change chart from May 1–15 to May 16–31. Average temperatures increased almost everywhere except in the Gulf and East Coast States where they decreased by 4°–8°F. Largest changes from the first 15 days occurred in the Northern Plains, 12°–16°F. higher, and in the West, 8°–12°F. higher.

Precipitation was very light over the western one-third of the United States during the last half of May. In the third week, locally heavy rain fell in the Southern Plains, and 1–2 in. fell from there to New England. A storm from Alberta during this period moved rapidly across the Lakes with severe weather limited to a few tornadoes in Illinois, Wisconsin, and Iowa. Other severe weather was reported in the Plains the fourth week, concurrent with the coastal storm described above. Here strong frontal activity produced hail and notably strong winds in the Central Plains, but generally less than an inch of rainfall.

5. SPRING 1967

The 700-mb. circulation pattern for Spring 1967 (fig. 11A) had considerable amplitude and resembled most the middle month of the season, April (fig. 1 of [1]). The record positive height anomalies of this month in the Atlantic and in the Gulf of Alaska helped produce record seasonal height anomalies.

In the Pacific the full-latitude ridge from Alaska southward was the strongest in the period of record (since 1933) in this area. Other spring seasons, notably 1963 and 1948, also had quite strong ridges here. The anomalous component of the flow implies a strong flow during the period from the Arctic to middle latitudes. This flow sustained the trough along the west coast and transported cool air into the West (fig. 11B). Associated with this trough was heavy precipitation in the West and in the northern Rockies (fig. 11C).

The ridge over the eastern one-third of the Nation, though not particularly strong, was persistent, with above normal heights over the area in which above normal temperatures prevailed. Below normal temperatures in the Northern Border States indicate the shallow penetration of continental air masses into the country because of the strong resistence caused by confluent flow.

Precipitation in the eastern half of the United States was heavy in the Lower Mississippi Valley and northeastward to New England. This seems to fit the actual flow fairly well with the heavy rainfall streaking across weak anticyclonic mean flow.

The weak trough southward from the Maritime Provinces was anchored by the record blocking ridge in the mid-Atlantic. The resultant flow brought lower than normal temperatures down the coast to the Middle Atlantic States. This cooling was supplemented by occasional onshore flow across abnormally cold ocean water along the coast from the Virginia Capes northward.

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1. R. A. Green, "The Weather and Circulation of April 1967—Numerous Temperature Extremes and Extensive Blocking," *Monthly Weather Review*, vol. 95, No. 7, July 1967, pp. 491–496.
2. Environmental Data Service, ESSA, *Weekly Weather and Crop Bulletin*, vol. 54, Nos. 23–25, June 5, 12, 19, 1967.
3. Environmental Data Service, ESSA, *Climatological Data, National Summary*, vol. 18, No. 5, May 1967.

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